LEAP

There's no doubt about it.
The field of dental technology is changing.

The ranks of old-school dental technicians are shrinking and along with them are disappearing many of the traditional technical skills and materials that were once relevant for analog production processing. Today, new generations of an ever-increasing number of materials—most of which are machineable—require digitally advanced production processes and a deeper understanding of material science among dental professionals for best-practices use.

Many believe these all-ceramic materials are quickly paving the way for metal-free dentistry with materials that are structurally sound, as well as more esthetic and biocompatible than their metal-based predecessors. However, their pace of arrival has been literally overwhelming the dental industry, prompting questions about evidence, philosophy, and patients' best interests.

of FAITH

Dilemmas in choosing and using the latest all-ceramic materials By Ellen Meyer

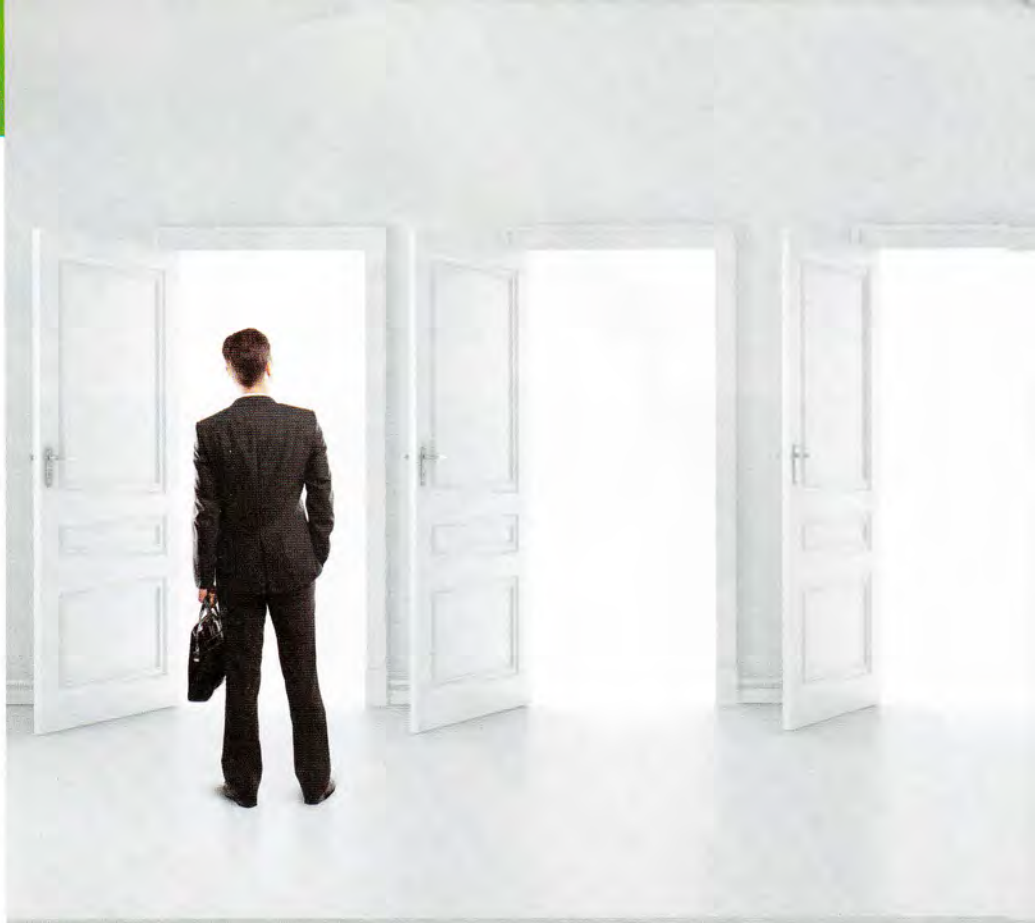
THE ISSUE OF EVIDENCE

As strong as the pressure is to keep up with the latest innovations, there are concerns about the dearth of long-term evidence to support choosing which among the newest materials is the best solution for the patient situation. Kenneth A. Malament, DDS, MScD, whose private practice, Boston Prosthodontics, is in Boston, MA, insists there is very little long-term survival data to clearly establish what these materials can and cannot do. "Every 6 months there seems to be a new material out there and the material has not gone through major assessment in either clinical trials or university testing."

Malament says proving the efficacy of a new material requires at least 5 full years of testing and 500 units. "If you don't have enough data, you don't have any real knowledge of how that material is going to behave. Will it discolor? Will it chip? Will it change its dimensional form? What happens if you adjust it? What will its bacterial adhesion be?"

Lee Culp, Chief Technology Officer, Microdental Laboratory, in Dublin, CA, agrees that there is little traditional evidence to support use of the newest all-ceramic materials. Materials are coming out so quickly and production processes and handling techniques are changing so much, he explains, that there are few studies or literature reports offering evidence-based criteria for use. "That is not to say there is no evidence—just not the scholarly documentation that has come to define 'evidence-based' in healthcare, and that it is a studied dental material observed in the mouth for 3 to 5 years." However, he adds, "There is observational evidence and clinical evidence, and there are standard laboratory material testing procedures carried out by the manufacturers that indicate these materials are likely to perform well." These tests, he explains, include the use of a mouth motion simulator to test the durability of new material or the 3-point bending test used at the University of North Carolina to load test a material—increasing pressure on the restoration, eg, a crown, until it breaks to find the "sweet spot" where esthetics and strength are optimized.

Steven McGowan, CDT, owner of Arcus Laboratory, in Kenmore, WA, since 1990, is treading carefully. McGowan says he relies heavily on evidence-based literature and makes a special effort to read and learn about new materials to be informed for the sake of his clients as well as himself. "I'm fascinated by the new technology but as a dental laboratory business owner, I need to be really careful." He says his reluctance to "jump in" without more long-term data about new products is due not only to the nature and clientele of his laboratory—a small, esthetic-oriented lab—but also his reputation for using proven equipment and materials. This, he says, gives him credibility with clients who have more confidence in the products and equipment he does choose to use.



He [Steve McGowan] says his reluctance to **"jump in"** without more long-term data about new products is due not only to the nature and clientele of his laboratory—a small, esthetics-oriented lab—but also his reputation for using proven equipment and materials.

For dentists and dental technicians who feel overwhelmed by the task of evaluating the ever-increasing number of materials on the market, J. Robert Kelly, DDS, PhD, offers several strategies.

Kelly, who is Professor, Reconstructive Sciences at the University of Connecticut Health Center, Farmington, CT, says the quarterly *Journal of Evidence-Based Dental Practice* offers summaries of clinical trials focused on a specific issue, with "well informed information about materials, techniques, drugs, etc."

He says those concerned about evidence can also gain a sense of the material's likely efficacy based on similar known materials. "While there may be a limited amount of information on the latest ceramic materials per se, knowing what the ceramic is made of places it in certain categories with products that have been on the market for

decades in terms of known clinical indications."

Kelly himself has developed a classification scheme for ceramics based on the matrix and filler particles (see Table 1). "These new products that come out fit in really nicely in existing categories and the categories we used when we last redid ISO 6872, which is the international dental ceramics standard."

CLINICAL MATERIAL SELECTION

All clinicians interviewed stressed the importance of matching the material to the specific patient and indication. "I have to choose the right materials to create restorations for my patients that will: fit really well; have great color so they feel it really looks just like a natural tooth; that will last a long time without breaking, chipping, discoloring, or losing its shine; and offer good occlusion/bite," says Malament.

With those goals in mind, material choice on a given patient, says Culp, takes into consideration many different factors. "Everything in the oral environment is taken into account, including the type of restoration: Is it an implant? Are we making a bridge? How long is the bridge? As an example, if you are doing a full-mouth implant-supported restoration, you need to consider how it will be all blended and bridged together. You wouldn't want to use IPS e.max® on a posterior bridge. It's not strong enough nor indicated for that use. IPS e.max is optimal, however, for anterior restorations, where stresses are lower. When restoring the posterior teeth, bite forces get much, much higher. When we go into fabricating posterior restorations, we can use metal ceramics—the most tested, most researched of any material used in the mouth today. We know it works. We have a lot of precedents for that."

Because his criteria for material selection includes predictability as well as strength and biocompatibility, Middleburg, VA, private practitioner, Gregg Helvey, DDS, says in large measure, the choice of material is based on the material the dentist is most comfortable and most successful with. For this reason, he calls it "a no-brainer" to choose either zirconia or lithium disilicate, but only when appropriate.

Helvey, who is also an Associate Professor at Virginia Commonwealth University School of Dentistry and a laboratory technician, says zirconia-filled ceramics are stronger than the materials used in the past (laboratory-processed composites) but not as strong or as hard as lithium disilicate or zirconia full-coverage crowns. There are situations—such as with patients who grind their teeth—where the use of a hard ceramic material such as a full-contour zirconia restoration can be used. The degree of wear of the antagonistic tooth is lower when the opposing is polished zirconia versus glazed zirconia, feldspathic, or lithium disilicate porcelain. "For those type of patients, choosing a fairly strong restoration but one that will not damage the natural opposing teeth is critical. In those situations, depending on the amount of occlusal clearance, you can go with a full-coverage zirconia crown or a zirconia-infused ceramic material," he maintains.

Helvey says ceramics alone cannot mask the color of a very dark tooth. In that type of situation, he says, he would lean toward a zirconia core type of restoration that would block out more of the light transferring through the restoration. "There are techniques that can mask the discolored tooth or cast post before taking the impression. The less

	MATRIX	FILLER	PROCESS	TRADE NAME
	ESTHETIC CERAMICS: *A. HIGH GLASS CONTENT*			
A.	Aluminosilicate Glass (Feldspathic or Synthetic)	High-Melting Glasses, Nepheline, Albite (approx. 40%)	CAD/CAM	Vitablocs Mark II
A.	Aluminosilicate Glass (Feldspathic or Synthetic)	Leucite (40%-50%)	CAD/CAM	IPS Empress CAD
A.	Aluminosilicate Glass (Feldspathic or Synthetic)	Leucite (40%-50%)	Pressed	IPS Empress Esthetic, OPC
A.	Aluminosilicate Glass (Feldspathic or Synthetic)	Leucite (40%-50%)	Powder	Optec, Cerinate
	STRUCTURAL CERAMICS: *B. LOW GLASS CONTENT* *C. NO GLASS CONTENT*			
B.	Special Silicate Glasses (High Lithium or Lanthanum)	Lithium Disilicate (70%)	CAD/CAM	IPS e.max CAD
B.	Special Silicate Glasses (High Lithium or Lanthanum)	Lithium Disilicate (70%)	Pressed	IPS e.max Press
B.	Special Silicate Glasses (High Lithium or Lanthanum)	Alumina, Spinell, Alumina/Zirconia (70%)	inLab or Dental Lab	In-Ceram Alumina, In-Ceram Spinell, In-Ceram Zirconia
C.	Alumina	Mg (3%) (Control Grain Growth)	inLab, CAD/CAM	Vita AL-Cubes, Procera
C.	Zirconia	Yttrium (3%-5%) (Transformation Toughening)	inLab	Vita YZ-Cubes, IPS e.max ZirCAD
C.	Zirconia	Yttrium (3%-5%) (Transformation Toughening)	CAD/CAM	Lava, Cercon, Procera

TABLE 1: Classification scheme for ceramics based on matrix and filler particles (courtesy J. Robert Kelly, 2008)

desirable situation would be that you would have to use metal (hopefully yellow gold) that would block out the underlying color."

When evaluating patients, he says, it is important to determine the type of chewer the patient is (rat or bear) and whether they have parafunctuonal habits when selecting the restorative material.

Kelly asks patients directly what they want in terms of esthetics, durability, and cost. He considers, too, whether a material can be bonded and etched because bonding ceramics is important for increasing their durability.

While McGowen agrees that material strength is important, he says the charts produced by the manufacturers generally don't differentiate the different types of strength—flexural, compressive, tensile—that should be factored into the choice of one material over another. "If a crown breaks, the dentist will say I think we need to go with something stronger, but they really don't what strength is and don't fully understand why it broke in the first place. For example, for something under compressive stress, aluminum oxide is stronger than zirconium oxide ceramic. Zirconia has a super high flexural strength—in nearly the same category as steel—but when did we determine that steel was a good thing to put in the mouth?"

McGowan says he believes in tried and tested materials including gold and conventional porcelain. "I'm not against the new materials—just cautious—I'm happy to use them because I'm in business to make money, too."

Both Kelly and Edward A. McLaren, DDS, MDC, consider "dental philosophy"—for example, whether patients would be agreeable to the "forever maintenance" required of resin-based composites, which will wear and break, but won't require aggressive tooth structure removal.

McLaren, who is Clinical Professor, Founder, and Director, UCLA Post Graduate Esthetics; Director, UCLA Center for Esthetic Dentistry; and Founder and Director of the UCLA Master Dental Ceramist Program at UCLA School of Dentistry, Los Angeles, CA, admits he "guides" patients to the more conservative options with questions such as "Is it more important to you to have the prettiest restoration or have the most conservative restoration, with the least amount of damage to your tooth?" or "Is it more important to have a restoration less likely to

REAL-WORLD MATERIAL TESTING

As McLaren's comment suggests, the relatively lax pre-market testing of dental materials has historically been a problem in dentistry, that the luxury of extensive—and expensive—clinical testing, which most medical products are required to undergo, has generally not been afforded dental products. McLaren says the fundamental reasons are "cost factors and how quickly things change," so, while the companies comply with FDA requirements for introducing a new material by proving—somewhat paradoxically—that the product is similar in formulation to something already on the market but that it's new and unique, "the FDA is primarily concerned about whether the material is toxic, not whether the restorations made with it will break or discolor."

It seems pre-market testing requirements and the rapidity of product introductions are not unrelated. As noted by McGowan, dental materials can be cranked out at the rate they are at least in part because they aren't subjected to the same level of scrutiny reserved for higher-stakes products with the potential to do greater harm. "Bad dentistry doesn't kill people; it just costs people more money," says McGowan.

In reality, it is not the manufacturers, material testing laboratories, or universities, but the dentists, laboratory technologists, and their patients who are the real-world testers—some say guinea pigs—who determine the success or failure of a material, says McLaren.

McLaren says he is concerned on multiple levels—as a clinician, as an educator, and as a scientist—but says that in fact, even the most arduous in-vitro testing doesn't necessarily transfer to real-world clinical success, and there are often large discrepancies between those tests. "For example, with ceramics, the number one reason for clinical failure relates to fracture. And we don't find a direct correlation from strength studies to clinical success. The assumption is that because some material reports high strength numbers, that automatically equates to high clinical success. But the problem may lie not with the material inherently, but with prepping or processing flaws developed during fabrication, or stresses caused when a material was veneered, which prestressed a material that led to early clinical failure—none of which is predictable from pure strength studies."

Lee Culp agrees that it's hard to get around the problems with compiling truly applicable evidence when there are so many variables in the real world of dental practice. "In a clinical study, everything is very, very controlled. But when that same material is introduced to the masses, anything can happen—the dentist may make it too thin, prepare the tooth incorrectly, or use cement incorrectly or not at all; or the laboratory may process it incorrectly. There is considerable study that goes into the materials before the product hits the market because dentists and technicians can do so many things that may be inappropriate for that material."

As an example, McLaren points to early versions of lithium disilicate/ porcelain combinations—and early versions of zirconia/ porcelain systems. "Both had different types of thermal issues that led to very early clinical failure, yet both systems reported excellent in vitro data. Both systems learned from the processing issues that led to failure and the current versions have had excellent clinical success in our system at UCLA."

Needed lessons about materials were also learned through trial and error in the 1960s and 1970s, says McLaren. "We wouldn't do metal ceramics today if we based our decisions on what happened when non-precious metals were introduced without sufficient clinical testing. So, every 5 to 10 years we seem to have the same problem, just with a different materials."

chip or break—like a PFM—although it's a fairly aggressive procedure?"

Recalling his days as a self-described "crownologist", the prosthodontist says his preference now is to start with the option with the lowest biologic cost that will last for a reasonable amount of time—ie, 10 years or longer.

"If I believe a conservatively prepped porcelain veneer has a more than 90% chance of surviving more than 10 years, that will be my first choice. If I believe porcelain veneers have a high risk of failure, the next least aggressive choice for me would be the monolithic IPS e.max all-ceramic veneer with no porcelain on it." Even IPS e.max, when cut back and layered with porcelain, can still have with problems such as chipping, he says.

McLaren is well aware of the dilemma dentists face when contemplating whether to use a new technique or material. "You want to stay competitive and offer what your patients are asking for, but you also want to have all the evidence so you can feel comfortable with that ethically."

Therefore, he says, his decision to shift to a new material is based on his preference for conservative approaches: "If it fails, I still have all the options I had previously. At worst, there is a price to pay only in time and money; the patient doesn't pay a biological price for somebody's lack of research."

NEW MATERIAL DEVELOPMENT GUIDELINES

McLaren says manufacturers should apply the lessons learned during the trial and error process of creating IPS e.max by developing ceramics that are inherently stronger and processing techniques that are inherently better. And then, dental professionals should adhere to the processing and handling protocols outlined by the manufacturer.

Certainly that has been the case with zirconia-based products, which have been around since the 1990s. Once the processing and handling issues were worked out—as was the case with PFM in the 1960s and alloys in the 1970s—the problems with fractures were corrected. This, he says, is also the case now with lithium disilicate. "Now, this is such a strong material and processes so well, even an average dentist with an okay technique, can prescribe and seat the material with an almost 0% failure rate. That is the benefit of a better material. The better materials minimize technique sensitivity."

"If I believe a conservatively prepped porcelain veneer has a more than 90% chance of surviving more than 10 years, that will be my first choice."

—Edward A. McLaren, DDS

McLaren is straightforward with patients about restoration material risks. "When patients ask how long a restoration will last, I say, 'Everything is a probability, but if you are one of the 7% who has a problem instead of the 93% who don't, you won't be a happy camper.'" However, he adds, "I will guarantee the clinical and laboratory work for 2 years. If it fails before then, it was probably a technical error. If it fails after then, it was probably something we couldn't control."

Given the remarkable success of zirconia and lithium disilicate for bonded monolithic restorations, McLaren says it should come as no surprise that other companies are rushing into the market with competitive all-ceramic formulations. DENTSPLY'S zirconia-reinforced lithium silicate, Celtra™ Duo, for conventional pressing or automated processing; Suprinity, zirconia-reinforced lithium silicate from Vident, which comes on the heels of its VITA® Enamic® for the CEREC®/inLab®, a hybrid ceramic suitable for posterior crowns that facilitates thinner walls for minimally invasive restorations; and Glidewell's Obsidian™ lithium silicate for monolithic crowns, 3-unit bridges, veneers, and inlays/onlays. Even new resin nano ceramic materials, such as 3M ESPE's Lava™ Ultimate, formulated for CAD/CAM manufacturing of crowns, inlays, onlays, and veneers, are gaining traction among dental professionals.

McLaren says manufacturers are also focusing on making a more translucent zirconia, "something with the translucency of lithium disilicate but maybe with twice the inherent strength." This, he says, is "theoretically possible because they are tweaking the amount of cubic zirconia."

That the body of evidence is mounting in favor of the most popular products is inspiring confidence as well as competitive fever, says McLaren. "We do have a clinical history with all the top choices right now and, over the last number of years, have been able to verify that they are all working if they are used correctly, so, there is no real contraindication for all-ceramics in the right situation.

FACING THE FUTURE

For Malament, the test of time is what matters most. "Technicians do very well with metal ceramics. We've got 35 years of evidence to prove it, but now metal ceramics is really only for complex reconstructions and in the most challenging color issues anteriorly." Yet Malament also recognizes that the influx of new CAD/CAM equipment and materials that are beginning to flood the market are transforming the industry. "In 5 to 10 years, we might be a profession where if you don't prescribe a CAD/CAM manufactured restoration, you might not get your laboratory work done."

McGowan, too, sees the writing on the wall. "I don't want to have my head in the sand. But because of the size of the lab that I have, I don't want to be one of the first adopters. I want the evidence to start to help make a decision for me. I'm not a widget maker—I'm a healthcare professional and believe that the healthcare profession should be held to a different standard."